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LUMBER RECOVERY FROM LIVE AND DEAD LODGEPOLE PINE IN SOUTHWESTERN WYOMING

by

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Abstract

A sample of 120 live and 147 dead lodgepole pine (Pinus contorta Dougl.) trees was selected in southwestern Wyoming to represent stands many timber managers and mill operators are processing. The trees were processed through a conventional circular headsaw sawmill to determine lumber yield and relative differences in product recovery. Of the total lumber volume for all live trees in the sample, 47 percent was graded Standard and Better, 17 percent Utility, and 8 percent Economy; for the dead trees, only 24 percent was graded Standard and Better, whereas 37 percent was graded Utility and 13 percent Economy. Based on the gross cubic volume of the log, the average cubic volume of lumber recovered was nearly the same for both live and dead trees--32 and 31 percent, respectively.

KEYWORDS: Lumber recovery, lumber yield, dead timber, lodgepole pine, Pinus contorta, Wyoming.

INTRODUCTION

The States of Utah and Wyoming contain an estimated 8-1/2 billion board feet (International 1/4-inch log rule) of commercial lodgepole pine (*Pinus contorta* Dougl.) sawtimber. Many stands include overmature and decadent trees, as well as dead trees; and many stands are overstocked. These stands present difficult problems to timber managers and timber buyers.

Many small mills in the Intermountain Region depend on lodgepole pine for a large proportion of their annual lumber production. With today's emphasis on environmental concerns and the Nation's increasing need for lumber, the vast volume of dead timber in these stands can no longer be ignored. Managers, buyers, and sellers of timber need reliable product recovery information to make sound evaluations in harvesting dead sawtimber.

Lack of information about this resource prompted a cooperative study between the Pacific Northwest Forest and Range Experiment Station, the Intermountain Region (R-4) of the National Forest System, and the Kamas Valley Lumber Company. The purpose of the study was to estimate the amount of lumber from a typical stand of live and dead lodgepole pine and to compare product recovery of live and dead trees.

METHODS

From a 10-acre area in Wyoming, 120 live and 147 dead trees were selected. About 55 percent of the trees were dead, probably since before 1960. Down trees were not included in the sample. The area was clearcut in 1976, and tree-length logs were skidded to the landing. At the landing, tops were bucked to a diameter of 4.5 to 5.0 inches, and broken tops and forks were cut off. This resulted in some larger top diameters. A sample of the tree length from the bucking point to the top was taken for each d.b.h. (diameter at breast height) class as the trees were yarded. An average length was later applied to the bucked trees for an estimate of total height.

All the trees were trucked to the millyard, and the sample to be processed was selected. A card with a number identified each sample tree. The intent was to select 20 dead and 20 live trees by 1-inch d.b.h. classes. This was easily accomplished in the smaller classes, but at the upper limits of the stand size it was more difficult. Therefore, the sample above 13-inch d.b.h. contains fewer than 20 trees per class since the stand did not contain many trees above that diameter.

Diameter and length of each log were measured so that both Scribner volume and cubic-foot volume could be calculated. Scribner scale was determined on the long logs (both live and dead) according to Forest Service Scaling Handbook rules. The dead logs were also scaled by deducting only soft rots, voids, and chars, and the reasons shown. The gross cubic volume of the log was calculated by Smalian's formula,

$$(0.002727)\ L(D_S^2+D_L^2);$$

where:

L = log length in feet,
D_S = diameter of the small end of the log in inches, and
D_L = diameter of the large end of the log in inches.

With these log volume calculations and the lumber tally volumes, the lumber recovery ratio (total lumber tally/net log scale) and the lumber recovery factor (LRF)[1] for logs and trees could be calculated.

Various curve forms using transformations of diameter correlated with cubic recovery percent were tested. The curve form selected was:

$$\text{Cubic recovery percent} = b_0+b_1D+b_2(1/D)+b_3(1/D^2);$$

where $b_0 \ldots b_3$ are the regression coeffieients, and D is the small end diameter of the log in inches.

The model chosen was based on the coefficient of determination and the standard deviation from regression, with the restriction that the same model be used for both live and dead logs.

Lumber Manufacturing

Equipment for processing lumber in the sawmill included a circular headsaw, two-saw scragg, double arbor edger, and trim saws. This equipment and the sawing, drying, and surfacing practices were representative for mills in the area. Identity of each log was maintained throughout the manufacturing process so that each piece of lumber tallied could be related back to the log from which it was derived. The lumber was tallied by its shipping dimension and grade. All lumber was graded under the supervision of a Western Wood Products Association grading inspector.

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[1] LRF = lumber recovery in board feet/gross cubic log volume.

RESULTS AND DISCUSSION

Lumber recovery is presented by log scaling diameter in tables 1 and 2 for the woods-length, live and dead logs, and in tables 3 and 4 by d.b.h. class for live and dead trees. When scaled by current USDA Forest Service methods, net scale of logs from dead trees was 17 percent of the gross scale (table 2); when sawn, the average cubic volume of lumber recovered was 32 percent for live logs and 31 percent for dead. The average cubic volume lumber recovery ratio for the dead logs and trees was only 1 percent less than that for the live. This ratio was calculated by dividing the sum of the cubic volumes of lumber by the sum of the cubic volumes of logs. Figure 1 shows curves of the cubic volume recovery ratio over diameter for live and dead logs.

Table 1--Log scale, lumber recovery, and cubic volume by scaling diameter for live lodgepole pine logs

Log scaling diameter	Number of logs	Log scale		Lumber tally		Cubic volume				
		Gross	Net	Volume	Recovery ratio	Log	Lumber	Lumber recovery ratio[1]	Sawdust	Residue
Inches		- - - Board feet		- - -	Percent	- Cubic feet	-	Percent	- - Cubic feet	- -
4	14	360	350	636	179	120.49	34.36	29	10.43	75.50
5	38	1,310	1,170	2,267	194	421.55	125.67	30	34.04	261.84
6	53	2,960	2,730	4,636	170	832.61	260.32	31	66.40	505.89
7	8	650	590	957	162	160.80	53.95	34	12.93	93.92
8	5	440	430	783	182	118.71	44.52	38	10.67	63.52
9	5	390	370	571	154	89.06	32.27	36	7.36	49.43
10	--	--	--	--	--	--	--	--	--	--
11	--	--	--	--	--	--	--	--	--	--
12	1	120	50	119	238	20.04	6.77	33	1.67	11.96
Total or average	124	6,230	5,690	9,959	175	1,763.62	557.86	32	143.50	1,062.26

[1] Based on gross cubic-foot volume of the log.

Table 2--Log scale, lumber recovery, and cubic volumes by scaling diameter for dead lodgepole pine logs

		Log scale			Lumber tally			Cubic volume				
						Recovery ratio						
Log scaling diameter	Number of logs	Gross	Actual net	Net, after deductions for rots, voids, and chars	Volume	Actual net[1]	Net, after deductions for rots, voids, and chars	Log	Lumber	Lumber recovery ratio[2]	Sawdust	Residue
Inches		- - - - - - - Board feet - - - - - - -				- - - Percent - - -		- Cubic feet -		Percent	- - Cubic feet - -	
4	7	160	20	150	292	1,460	195	48.54	16.22	33	4.96	27.36
5	23	1,190	210	1,110	1,777	846	160	378.82	98.54	26	27.77	252.31
6	64	3,770	760	3,590	5,704	751	159	1,039.22	320.45	31	80.77	637.96
7	25	1,800	200	1,730	2,449	1,224	142	435.65	138.45	32	33.54	263.66
8	5	390	110	380	598	554	157	106.75	33.78	32	8.33	64.68
9	8	840	70	810	1,353	1,933	167	199.64	76.86	38	17.89	104.89
10	7	740	120	740	1,151	959	156	183.93	65.45	36	15.48	103.00
11	1	120	0	100	122	--	122	22.14	6.89	31	1.71	13.54
12	1	150	50	140	171	342	122	30.54	9.71	32	2.31	18.52
Total or average	151	9,160	1,540	8,750	13,617	884	156	2,445.27	766.39	31	192.76	1,486.12

[1] Calculations should not be based on actual net for dead timber.

[2] Based on gross cubic-foot volume of the log.

Table 3--Tree scale, lumber recovery, and cubic volume by diameter class for live lodgepole pine trees

Tree d.b.h.	Number of trees	Tree scale		Lumber tally		Cubic volume				
		Gross	Net	Volume	Recovery ratio	Total tree	Lumber	Lumber recovery ratio[1]	Sawdust	Residue
Inches		- - - Board feet		- - -	Percent	- Cubic feet	-	Percent	- - Cubic feet	- -
7	2	40	40	77	192	16.14	4.11	25	1.28	10.75
8	19	470	400	720	180	138.72	39.60	29	11.74	87.38
9	31	960	880	1,572	179	286.81	86.53	30	24.96	175.32
10	21	970	910	1,502	165	293.93	83.79	29	22.20	187.94
11	18	1,090	1,030	1,829	178	330.04	102.74	31	25.58	201.72
12	19	1,420	1,210	2,320	192	409.99	131.20	32	31.25	247.54
13	2	260	240	416	173	63.95	23.63	37	5.69	34.63
14	7	920	860	1,332	155	233.47	75.55	32	17.90	140.02
15	--	--	--	--	--	--	--	--	--	--
16	--	--	--	--	--	--	--	--	--	--
17	--	--	--	--	--	--	--	--	--	--
18	1	130	50	119	238	35.13	6.77	19	1.67	26.69
Total or average	120	6,260	5,620	9,887	176	1,808.18	553.92	31	142.27	1,111.99

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[1] Based on gross cubic-foot volume of the tree.

Table 4--Tree scale, lumber recovery, and cubic volume by diameter class for dead lodgepole pine trees

		Tree scale			Lumber tally			Cubic volume				
						Recovery ratio						
Tree d.b.h.	Number of trees	Gross	Net	Net, after deductions for rots, voids, and chars	Volume	Actual net[1]	Net, after deductions for rots, voids, and chars	Tree	Lumber	Lumber recovery ratio[2]	Sawdust	Residue
Inches		- - - - - - - - Board feet	- - - - - - - -			- - - Percent	- - -	- Cubic feet	-	Percent	- - Cubic feet	- -
7	5	100	50	100	136	272	136	24.35	7.37	30	2.33	14.65
8	16	330	40	270	498	1,245	134	99.29	27.28	27	8.45	63.56
9	24	870	190	850	1,070	563	126	239.20	58.95	25	17.19	163.06
10	21	950	190	850	1,412	743	166	298.67	79.21	27	21.31	198.15
11	23	1,220	310	1,100	1,840	594	167	375.60	103.70	28	25.71	246.19
12	19	1,340	230	1,300	2,008	873	154	349.96	113.12	32	27.47	209.37
13	17	1,530	190	1,430	2,344	1,234	164	404.84	132.72	33	32.16	239.96
14	9	1,020	300	940	1,526	509	162	256.63	86.54	34	20.44	149.65
15	7	1,120	370	920	1,493	404	162	284.02	84.64	30	20.20	179.18
16	1	140	30	140	172	573	123	32.73	9.62	29	2.23	20.88
17	2	280	50	230	396	792	172	67.86	22.44	33	5.53	39.89
18	3	470	140	420	670	479	160	128.55	38.06	30	8.90	81.59
Total or average	147	9,370	2,090	8,550	13,565	649	159	2,561.70	763.65	30	191.92	1,606.13

[1] Calculations should not be based on actual net for dead timber.

[2] Based on gross cubic-foot volume of the log.

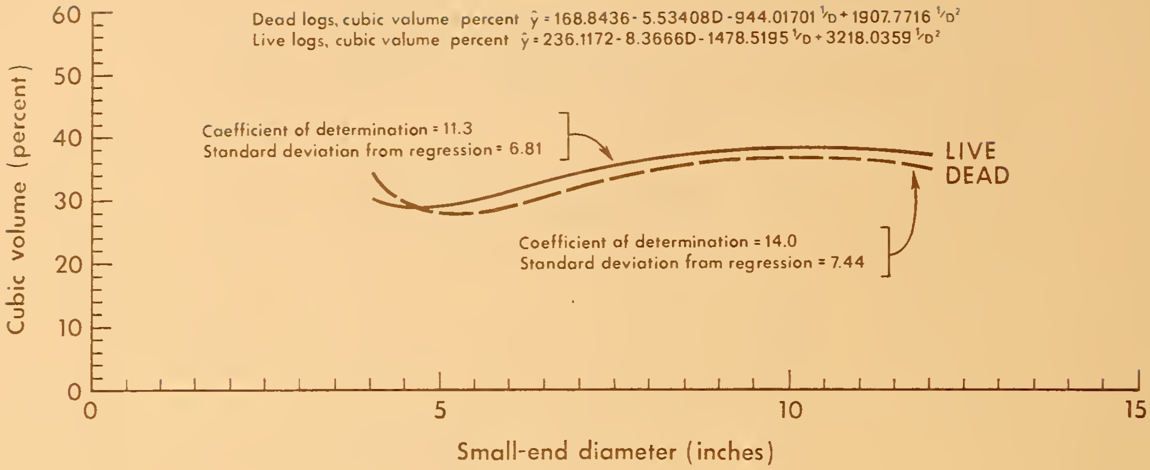

Figure 1.--Recovery of cubic volume curved over diameter for live and dead lodgepole pine logs.

Apparently, defect deductions for checks under the scaling rules do not adequately reflect the potential for recovery of lumber from dead timber. The reduction in lumber volume was much less than land managers and operators might expect. I think one reason the percentage of the lumber recovered from live and dead logs was so similar at a mill producing 4/4 and 8/4 lumber is that lumber no wider than 8 inches was produced. Another factor may be that the amount of spiral checking in these logs was less severe than in some stands of lodgepole pine. These factors would contribute to maximizing recovery from these logs.

Both the actual net volume and the net volume with deductions for soft rots, voids, and chars are shown for the dead logs in table 2. The corresponding recovery ratios for the two net volumes show that when the deductions for rots, voids, and chars are made, the recovery ratio is only slightly less than that for the live logs. For instance, table 2 shows an average recovery ratio of 156 when dead logs are scaled with deductions only for soft rots, voids, and chars compared with 175 for live logs (table 1) scaled by conventional methods. A similar relationship can be seen for the trees. Some recovery ratios exceed 1,000 percent when scaled by conventional methods. Such values are not valid functions of potential recovery from dead timber; I have shown them to stress the defect deduction method used on dead timber.

The cubic volumes of lumber shown in the tables are based on actual dimensions of the surfaced, dry lumber taken from the planer settings. Cubic volumes of sawdust were calculated from an average saw kerf of 0.25 inch and the computed surface area of the surfaced dry lumber; therefore, the volume of sawdust is conservative. Volume of residue was calculated by subtracting the volumes of lumber and sawdust from the gross cubic volume of the log. It then included the volume attributed to shrinkage and planer shavings plus a small amount of sawdust produced from slabs, edging, and trim ends.

This study produced 79-percent dimension lumber, all 2x4, 2x6, or 2x8; the other 21 percent was 1-inch lumber not over 8 inches wide. Tables 5 and 6 show lumber grade recovery as a percentage of lumber tally volume by 1-inch diameter classes for the live and dead logs; similar data are shown for live and dead trees in tables 7 and 8.

The average LRF, based on the surfaced dry lumber tally, for this study was 5.64 for the live logs and 5.57 for the dead. This is consistent with cubic-volume recovery percents for the live and dead logs.

Even though the cubic recovery ratios for the live and dead logs and trees are nearly alike, the differences in recovery by lumber grade are important, particularly in the dimension grades because of the loss in value from deterioration of the dead timber. The live logs and trees produced 47 percent of the total lumber tally volume as Standard and Better grade lumber, whereas only 24 percent of the lumber was graded Standard and Better for the dead logs and trees. The major reason for the difference is that the checking inherent in the dead material resulted in more Utility or No. 3 and Economy grade lumber; 17 percent of the recovered volume from live logs and trees was Utility or No. 3 and 8 percent Economy; the yield for dead logs and trees was 37 percent Utility or No. 3 and 13 percent Economy. Yield in stud grades was 6 percent for the live logs and trees and 5 percent for the dead. These relationships are depicted by diameter class in the histograms in figures 2 and 3.

Table 5--Lumber grade recovery by diameter class for live lodgepole pine logs

Log scaling diameter	Number of logs	Total lumber tally	Lumber grade												
			Moulding	No. 1 Common	No. 2 Common	No. 3 Common	No. 4 Common	No. 5 Common	Select structural	Construction or No. 1	Standard or No. 2	Utility or No. 3	Economy	Stud	Economy stud
Inches		Board feet	- Percent of total lumber tally volume -												
4	14	626	0.48	0.96	4.95	16.45	10.38	8.95	6.71	5.59	16.77	10.06	2.24	11.82	4.63
5	38	2,267	.35	.66	3.75	10.67	6.09	5.21	10.50	12.92	17.73	13.19	7.54	7.32	4.06
6	53	4,636	.24	1.23	1.19	9.04	4.85	3.71	16.76	12.36	19.67	17.49	8.09	3.47	1.90
7	8	957	--	.73	3.03	5.54	4.60	1.46	24.66	7.84	15.99	25.29	9.93	.42	.52
8	5	783	--	.38	3.83	5.62	2.68	4.85	32.18	10.34	10.22	23.50	5.11	1.28	--
9	5	571	.70	--	--	4.20	3.15	2.63	35.55	21.54	7.01	12.61	9.11	3.50	--
10	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
12	1	119	--	4.20	2.52	3.36	10.08	3.36	26.89	--	26.89	13.45	9.24	--	--
Total or average	124	9,959	.26	.93	2.34	8.93	5.25	4.19	17.87	11.85	17.31	16.94	7.61	4.37	2.15

Table 6--Lumber grade recovery by diameter class for dead lodgepole pine logs

Log scaling diameter	Number of logs	Total lumber tally	Lumber grade												
			Moulding	No. 1 Common	No. 2 Common	No. 3 Common	No. 4 Common	No. 5 Common	Select structural	Construction or No. 1	Standard or No. 2	Utility or No. 3	Economy	Stud	Economy stud
Inches		Board feet	- - - - - - - - - - - -	- - - - -	- - - - -	- - - - -	- - - - -	Percent of total lumber tally volume	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -
4	7	292	--	--	7.53	18.15	10.27	6.51	--	2.40	2.40	13.70	8.22	23.97	6.85
5	33	1,777	--	0.56	2.59	13.51	7.60	7.65	4.95	3.94	15.76	19.25	9.90	11.25	3.04
6	64	5,704	0.12	.05	1.28	7.42	5.94	5.43	4.68	4.70	16.09	35.83	14.13	3.28	1.03
7	25	2,449	--	.33	.29	4.74	5.23	5.19	7.51	4.08	14.90	44.47	10.45	2.04	.78
8	5	598	--	--	--	4.52	12.21	3.18	5.52	12.71	10.54	41.97	7.69	1.67	--
9	8	1,353	.22	.22	--	2.59	6.73	5.40	5.32	11.68	9.09	44.86	13.16	.74	--
10	7	1,151	.70	--	.26	5.65	5.13	6.69	5.04	7.65	7.04	41.44	20.42	--	--
11	1	122	--	--	--	8.20	13.11	3.28	--	--	--	54.92	17.21	3.28	--
12	1	171	--	--	5.26	2.34	8.77	2.34	--	--	8.19	49.71	20.47	--	2.92
Total or average	151	13,617	.13	.18	1.18	7.15	6.51	5.65	5.16	5.63	13.59	36.73	13.05	3.90	1.15

Table 7--Lumber grade recovery by diameter class for live lodgepole pine trees

Tree d.b.h.	Number of trees	Total lumber tally	Lumber grade												
			Moulding	No. 1 Common	No. 2 Common	No. 3 Common	No. 4 Common	No. 5 Common	Select structural	Construction or No. 1	Standard or No. 2	Utility or No. 3	Economy	Stud	Economy stud
Inches		Board feet	Percent of total lumber tally volume												
7	2	77	--	3.90	7.79	11.68	12.99	7.79	--	20.78	9.09	--	--	25.97	--
8	19	720	0.42	3.75	2.64	13.89	8.75	9.31	--	4.31	14.31	7.78	15.00	12.22	7.64
9	31	1,572	1.21	1.59	4.07	15.46	6.23	5.73	8.02	10.94	14.69	13.99	7.12	7.25	3.69
10	21	1,502	--	1.00	2.80	9.45	5.99	3.73	22.10	12.98	16.55	12.52	3.99	6.72	2.26
11	18	1,829	--	.44	1.37	6.62	5.25	2.95	14.00	10.11	25.86	22.58	7.49	2.08	1.26
12	19	2,320	.17	--	1.12	5.26	3.19	4.35	21.64	16.25	15.73	21.03	8.66	1.51	1.08
13	2	416	--	--	5.53	5.77	5.05	.72	35.10	8.41	19.95	8.89	6.01	2.16	2.40
14	7	1,332	--	.75	1.43	8.18	3.45	2.70	28.98	12.69	13.06	20.20	7.81	.75	--
15	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
16	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
17	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
18	1	119	--	4.20	2.52	3.36	10.08	3.36	26.89	--	26.89	13.45	9.24	--	--
Total or average	120	9,887	.26	.94	2.30	8.84	5.16	4.22	18.00	11.93	17.35	17.06	7.67	4.20	2.07

Table 8--Lumber grade recovery by diameter class for dead lodgepole pine trees

Tree d.b.h.	Number of trees	Total lumber tally	Lumber grade												
			Moulding	No. 1 Common	No. 2 Common	No. 3 Common	No. 4 Common	No. 5 Common	Select structural	Construction or No. 1	Standard or No. 2	Utility or No. 3	Economy	Stud	Economy stud
Inches		Board feet	- - - - - - - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - -	Percent of total lumber tally volume	- - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -
7	5	136	--	--	12.50	22.79	8.82	2.21	--	5.15	--	--	11.03	30.15	7.35
8	16	498	--	1.41	5.42	19.88	5.62	10.64	--	5.42	13.25	11.85	3.41	18.07	5.02
9	24	1,070	--	.47	2.62	16.82	10.19	5.89	0.93	5.05	14.86	19.72	12.34	8.88	2.24
10	21	1,412	--	--	2.34	11.05	7.22	6.02	10.76	6.02	18.34	18.06	13.46	5.31	1.42
11	23	1,840	--	--	.33	4.62	6.52	4.62	3.70	4.08	19.51	33.97	15.33	5.43	1.90
12	19	2,008	--	--	.80	5.18	5.28	4.23	5.33	3.54	16.78	42.03	12.30	3.88	.65
13	17	2,344	0.30	.26	.43	5.25	6.10	5.67	9.56	3.37	9.47	45.78	12.46	1.37	--
14	9	1,526	.72	--	.20	3.93	5.24	6.16	4.00	15.07	13.30	43.45	7.27	.33	.33
15	7	1,493	--	--	.87	4.55	8.37	5.02	2.88	6.43	8.71	48.36	14.13	.33	.33
16	1	172	--	--	--	3.49	3.49	2.91	--	6.40	9.30	43.60	25.00	2.91	2.91
17	2	396	--	--	1.26	4.29	6.82	9.60	--	--	15.91	38.64	22.22	--	1.26
18	3	670	--	--	--	6.12	4.18	5.67	5.52	4.78	4.48	48.06	21.19	--	--
Total or average	147	13,565	.13	.13	1.16	7.15	6.53	5.58	5.18	5.65	13.59	36.87	13.05	3.88	1.08

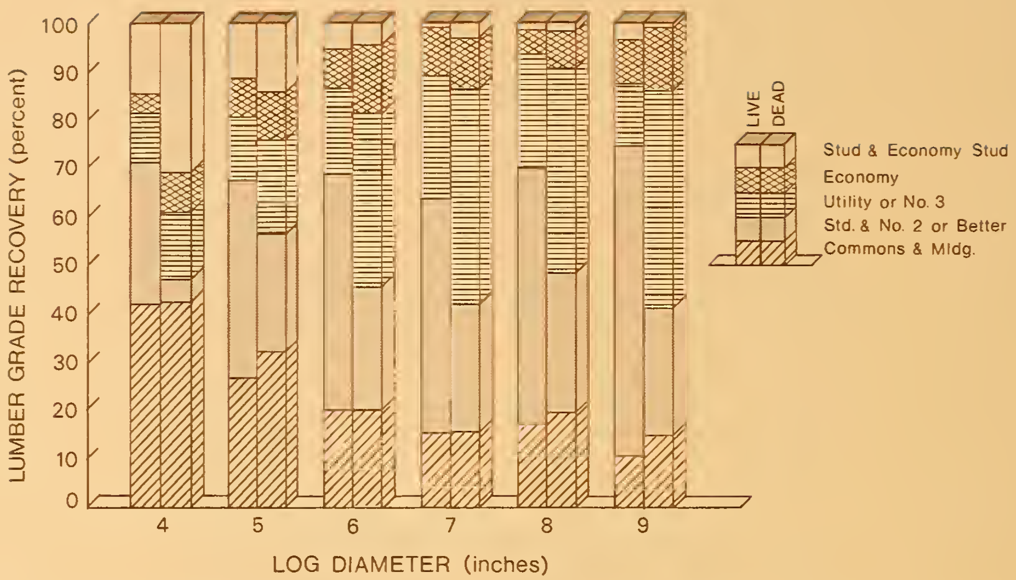

Figure 2.--Percent lumber grade recovery by diameter class for live and dead lodgepole pine logs in Wyoming.

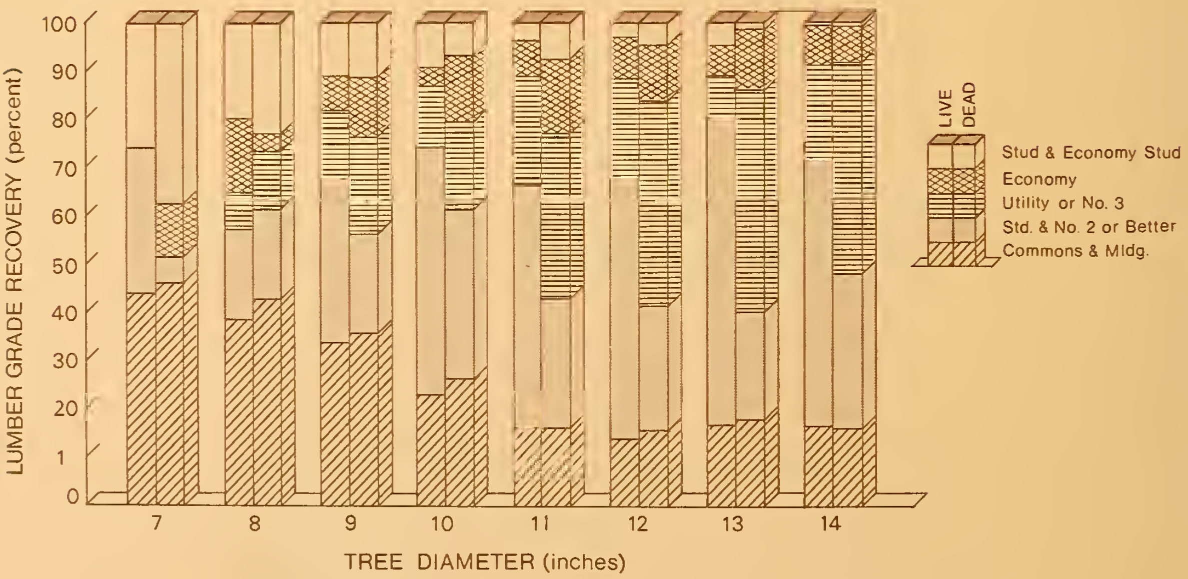

Figure 3.--Percent lumber grade recovery by diameter class for live and dead lodgepole pine trees in Wyoming.

SUMMARY

Standing dead lodgepole pine presents an opportunity for utilization of a resource that can extend the Nation's timber supply, but there are potential problems because of defect, small timber, and reduced grade yields. In this study, nearly the same amount of lumber was recovered from dead material as from live material, but the dead material showed a marked reduction in grade recovery compared with the live. The amount of checking present in the logs was the primary reason for the lower grade of dead logs.

Metric Equivalents

1 inch = 2.54 centimeters
1 cubic foot = 0.028 3 cubic meter
1 acre = 0.404 7 hectare

GPO 990-058

The FOREST SERVICE of the U.S. Department of Agriculture is dedicated to the principle of multiple use management of the Nation's forest resources for sustained yields of wood, water, forage, wildlife, and recreation. Through forestry research, cooperation with the States and private forest owners, and management of the National Forests and National Grasslands, it strives — as directed by Congress — to provide increasingly greater service to a growing Nation.

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